THE COMPLEX RELATIONSHIP BETWEEN TEACHERS' MATHEMATICS-RELATED BELIEFS AND THEIR PRACTICES IN MATHEMATICS CLASS

By Yoppy Wahyu Purnomo

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Abstract
Mathematics-related beliefs have an important role in giving a teacher directions for taking decisions and for their behavior in a mathematics class. Therefore, the purposes of this research are to reveal the profile of teachers' mathematics-related beliefs, the consistency among belief dimensions, the teachers' practical profile in a mathematics class, and the consistency between beliefs and teachers' practices in a mathematics class. This research used surveys with a cross-sectional design to collect data from 325 elementary school teachers in Jakarta. Teachers' beliefs instruments and teachers' practices in mathematics class were used to collect the data. The findings of this research indicate that teachers tend to be constructivism-oriented but are not accompanied with the suitable practices in mathematics class. More than that, complex relationships also occur in both belief dimensions and in their relationships with the practices in a mathematics class.
Key words: *teacher beliefs, teacher practices, mathematics class, elementary school teachers*

Introduction

The gap between education research and its practice is a critical issue which has become a contention among researchers, practitioners, and policy-makers (Broekkamp & van Hout-Wolters, 2007; Vanderlinde & van Braak, 2010), including in the area of mathematics education research and the practices of mathematics in class. Many potential factors contribute to the gap. From the usability and the practical value of the researcher's point of view, Broekkamp and van Hout-Wolters (2007) said that the teachers' negative belief about research is one of the potential factors, causing them to reluctantly apply it in class. As found in literature, belief is a variable which has a role in guiding someone to take decisions and to behave in class (Ernest, 1989; Purnomo, Suryadi, & Darwis, 2016). In other words, when fundamental theories and research suggestions are parallel with a teacher's belief, then the belief will lead the teacher to apply it in class. A mathematics teacher has an important role in creating meaningful mathematics learning to the students. Besides content knowledge, pedagogical knowledge, and pedagogical content knowledge, a teacher's mathematics-related beliefs become variables that also have a role in guiding that knowledge to create meaningful mathematics learning. This was illustrated by Ernest (1989) about the role of belief which was exampled by two mathematics teachers who potentially had the same knowledge, but perhaps one teacher taught mathematics through a problem-solving orientation and the other teacher had a more didactic approach.

The teachers' beliefs system has multifaceted constructs. According to Ernest (1991), teachers' mathematics-related beliefs cover beliefs about the nature of mathematics, beliefs about mathematics teaching, and their beliefs about assessment. Ernest (1989) stated that someone's beliefs about the nature of mathematics are strongly related to mathematics' philosophy as the disciplines. When mathematics is believed as static knowledge or has an absolute validity which covers a set of rules, facts, or procedures used to get a right answer, their beliefs of teaching lead them to teach through a transmission model which is signed by exposure, exercising, and memorizing known as instrumental teaching. In other words, the teaching option taken is how to guide students to be skilled and efficient in procedural operations and symbol manipulations without understanding the meaning and the reason behind it. Constructivism shows that in order to build knowledge, learners must actively build it by themselves either through experiences they had or by interactions. Here, the teacher is the learning facilitator who provides the students opportunities to be involved in meaningful mathematics problem solving.

Besides the teachers' beliefs about the nature of mathematics and mathematics teaching, responding to the teachers' beliefs about assessment is important to predict, to design, and to pick the rational decision to support the mathematics learning process (Purnomo, 2015). Assessment is a set of integral activities in the mathematic learning process which provides information for both the teachers, who make the teaching decisions, and the students to know the learning progress and to reflect on certain points that need to be leveled up (Purnomo, 2015, 2016b). As assessment is an integral part of the learning process, Delandshere and Jones (1999) said that when learning is believed as facts, rules, and skills acquisition, the assessment tends to be looked as a way to give sanctions and verifications. On the other side, if the learning is believed as a continuous building process strengthened by structural, purposeful, and educational experiences, then the assessment tends to be perceived as a documentation and feedback provision. Therefore, besides the beliefs of the nature of mathematics and mathematic teaching itself, it is important to respond to the teachers' beliefs of assessment in mathematics learning.

A teacher's mathematics-related beliefs are built since the early days when they acquire experience, especially school experience, and peak when they acquire experiences at the college level. Regarding this, the education for elementary school teacher candidates in college does not specifically study mathematics. Therefore, this research focused on examining the elementary school teachers' beliefs so that we can acquire ideas and suggestions for elementary school teacher preparation at the college level.

In literature, previous studies have examined the relationship between a teacher's mathematical beliefs and their teaching practices in mathematics class (Stipek, Givvin, Salmon, & MacGyvers, 2001; Wijaya, van den Heuvel-Panhuizen, & Doorman, 2015). There are also studies that have examined the relationship between beliefs about assessment and assessment practices in class (Azis, 2014; Calveric, 2010). Nevertheless, there is a lack of large-scale studies which comprehensively examine the relationship between belief variables (i.e. the nature of mathematics, teaching and learning, and assessment), as well as their relationship with the practice of teaching and assessment in a mathematics class. Stipek et al. (2001) had started to examine the relationship between teachers' beliefs about mathematics, teaching and learning, and its relation to the teaching and assessment practices. However, these studies do not focus on assessing beliefs about assessment and its relation to assessment practices in mathematics class. Furthermore, there are also few literature findings on studies that examine teachers' beliefs and practices in mathematics class in the context of teachers in Indonesia. Based on these reasons, this research endeavored to contribute as both theoretical and empirical knowledge as a complement to previous studies.

This research has the purpose to reveal the teachers' mathematical belief profile, consistency among belief dimensions (factor), the teachers' practical profile in a mathematics class, and consistency between beliefs and the teacher's practices in mathematics class. For these purposes, there are four research questions which will be discussed, which are (1) What are the mathematic-related beliefs that tend to be held by teachers? (2) Is there any consistency among suitable belief factors held by the teachers? (3) What is the practical tendency conducted by the teachers? (4) Do the teachers' practices in the mathematics class reflect what they believe?

Method

Participant

This research used a survey with a cross-sectional design. The participants who became samples were 325 elementary school teachers (69 public schools and 6 private schools) in East Jakarta during the 2015/2016 academic year which were selected conveniently. This method was conducted because it was not expensive, did not need much time, and was easily administered. It was started by choosing one of six cities in Jakarta. Then, the elementary schools in that selected city were selected randomly. Next, the teachers of those selected schools participated conveniently. The participants consisted of 80.9% female and 17.5% male, while 1.5% of those were not clear. Of the participants, 12.3% of them had 3 years or less experience, 22.2% had 4-10 years experience, 21.8% had 11-20 years experience, 4.6% of them had more than 20 years experience, and 3.1% of them were not clear.

Instrument and procedure

The instruments of this research were two questionnaires: teachers' mathematic-related beliefs and teachers' practices in a mathematics class. The belief and the practice scales were developed according to the literature and analyzed by factor analysis. An exploratory factor analysis was used to build the factor structure and then confirmed by a confirmatory factor analysis. The detailed analysis of those statistics could be found in Purnomo (2016a). The questionnaire of teachers' mathematic-related beliefs consisted of three subscales. There were 9 items for beliefs about the nature of mathematics (BNM), 11 items for beliefs about the teaching of mathematics (BTM), and 10 items for beliefs about the assessment of mathematics learning (BAM). All subscales had adequate construction validity (convergent and discriminant validity). The alpha coefficient had the range of 0.715 and 0.787, so it had adequate internal consistency coefficient. On the other side, the questionnaire of the practice in a mathematics class covered 11 items for teaching practice (TP) in mathematics class and 11 items for assessment practice (AP) in mathematics class. Construction validity for each subscale of teachers' practice in mathematics class was at a good level. Internal consistency was also above adequate level, which was in a range of coefficient 0.704 to 0.742 for each subscale.

Data Analysis

The first and third questions were analyzed using descriptive statistics such as mean, standard deviation, and mean range. In order to see the data tendency from every factor, a t-test with 5% significance level was conducted. The effect size (ES) was also used to complete and see how big the impact was. The Spearman correlation test was performed to see the consistency among the belief factors and to see the consistency between the belief teachers held and the practice conducted in the mathematics class.

Results

Research question 1: What are the mathematics-related beliefs that are tend to be held by the teachers?

The data of dynamic factor at BNM are negated first and given the absolute label. The result of the analysis can be seen in Table 1.

Table 1. Comparison among factors at BNM, BTM, and BAM

Subscale	Factor	*Mean*	SD	Mean range of items	Mean comparison	*ES*
BNM	Relevant	5.012	0.569	4.594 – 5.432	$t(322) = 13.849$;	0.771
	Absolute	4.072	1.130	3.970 – 4.272	$p = 0.000$	
BTM	Relational	5.032	0.474	4.836 – 5.352	$t(317) = 8.950$;	
	Instrumental	4.635	0.748	4.484 – 4.849	$p = 0.000$	0.502
BAM	Integrated	5.122	0.458	4.478 – 4.897	$t(317) = 10.646$;	0.597
	Isolated	4.782	0.628	4.997 – 5.270	$p = 0.000$	

As presented in Table 1, the teachers' beliefs about the nature of mathematics are more dominated by their view about relevant mathematics than their absolute view (p-value < 0.05). This difference is also supported by the ES score of 0.771 which can be considered as a large difference. A significant difference (p-value < 0.05) also occurs on the teachers' belief factors about teaching. The findings indicated that the participants tend to have a more relational teaching view than an instrumental one. An ES score of 0.502 shows that the size of the difference between them is medium. Meanwhile, the BAM that is held by the teachers is dominated by a view that assessment is an integral part of the learning process. The significant difference is shown by the p-value < 0.05 and this medium sized difference is shown by the ES score of 0.597.

Research question 2: Is there any consistency among suitable belief factors?

The Spearman correlation analysis was chosen to see the relationship among the belief factors. The results of the analysis can be seen in Table 2.

Table 2. Correlation among factors on the belief scale

Subscale	Factor	1	2	3	4	5	6
BNM	**1** (Relevant)	1	-0.137*	0.016	0.068	0.107	-0.043
	2 (Dynamic)		1	0.020	0.042	0.019	0.045
BTM	**3** (Relational)			1	0.238**	0.270**	0.137*
	4 (Instrumental)				1	0.250**	0.226**
BAM	**5** (Integrated)					1	0.435**
	6 (Isolated)						1

**. *Correlation is significant at the 0.01 level (2-tailed)*

*. *Correlation is significant at the 0.05 level (2-tailed).*

Based on Table 2, the consistency is shown by a significant correlation between the relational factor and the integrated factor at the 1% level of significance. A significant correlation is also shown by the instrumental teaching factor and the isolated factor at the 1% level of significance. On the other hand, the dynamic and relevant factors in the BNM subscale both have a weak correlation to other factors. Nevertheless, those two factors have a significant negative correlation ($\alpha = 5\%$) as indicated by the correlation coefficient value of -0.137. A significant correlation among factors in the same subscale also occurs on BTM and BAM. The relational factor correlates positively to the instrumental factor ($\alpha = 5\%$). A similar result is shown by the integrated factor which has a significant correlation with the isolated factor($\alpha = 1\%$) . This result also implies logically with the correlation among the results of factor analysis which indicate inconsistency among belief factors such as between the relational and the isolated factor as well as the instrumental factor and the integrated factor.

Research question 3: What is the teacher's practical tendency in mathematics class?

The analysis to answer the third question is similar with what was conducted to answer the first question. The results of the analysis are shown in Table 3.

Table 3. Comparison among factors on TP and AP in mathematics class

Subscale	Factor	*Mean*	SD	Mean range of items	Mean comparison	*ES*
TP	Instrumental	4.324	0.469	4.100 – 4.540	$t(324) = 17.862$;	0.991
	Relational	3.619	0.593	3.357 – 3.969	$p = 0.000$	
AP	*AoL*	4.477	0.449	4.158 – 4.676	$t(322) = 25.225$;	1.404
	AfL	3.347	0.714	3.053 – 3.622	$p = 0.000$	

As shown in Table 3, the TP profile is intended more to emphasize an instrumental practice than a relational one. The difference is significant due to the p-value which is less than 0.05 and has a large-sized difference because the ES score is 0.991. A significant and very large difference is also found at the AP. The significant difference is shown by the p-value, which is less than 0.05, and a very large-sized difference is shown by the ES score, which is 1.404. In other words, AP conducted by the teacher tends to be A*o*L practice than A*f*L in mathematics class.

Research question 4: Do the practices conducted in the mathematics class reflect the beliefs held by the teachers?

The analysis using Spearman correlation was conducted to know the correlation between the beliefs and the practices in mathematics class. The results of the analysis can be seen in Table 4.

Table 4. Correlation between belief factors and practice factors.

Beliefs		Practices			
		TP		AP	
	Factor	Relational	Instrumental	AfL	AoL
BNM	1. Relevant	0.184**	0.131*	0.100	0.149**
	2. Dynamic	0.052	-0.042	0.001	-0.067
BTM	3. Relational	0.171**	-0.016	0.078	0.028
	4. Instrumental	0.097	0.070	0.140*	-0.064
BAM	5. Integrated	0.077	0.119*	0.062	0.030
	6. Isolated	-0.004	0.125*	0.214**	0.027

**. *Correlation is significant at the 0.01 level (2-tailed)*

*. *Correlation is significant at the 0.05 level (2-tailed).*

Based on Table 4, there seems to be some consistencies between the beliefs and practices in the mathematics class shown by (1) the relevant factor and the relational teaching practice factor; (2) the relational factor and the relational teaching practice factor; and (3) the isolated factor and the instrumental practice. On the other hand, an inconsistency can be shown by the significant correlation (α = 5%) between the instrumental teaching practice and the relevant factor at the BNM. The instrumental teaching practice also has a correlation with the irrelevant factor; there is an integrated factor at the BAM. Some other inconsistencies can be seen by the significant correlation between the A*f*L practice to instrumental factor at the BTM and the integrated factor at the BAM.

Discussion

The research results indicate that the teachers in this study tend to hold the belief of constructivism, either on their belief about the nature of mathematics, mathematics teaching, or about the assessment in mathematics learning. It is parallel with the results from earlier researchers (Purnomo et al., 2016; Wijaya et al., 2015) that similarly indicate that teachers tend to have constructivism view. Nevertheless, the teachers' responses are not fully consistent in one category. For example, in this research, the teachers tend to agree that mathematics teaching is important to understand the relevant problem and context, but on the other side they also agree that mathematic problem solving should be done quickly and instantly. The other contradiction in one category can also be found at the beliefs about the nature of mathematics and the assessment in mathematics class. The contradiction can also be verified by looking at the significant correlation among factors in one category. More than that, the analysis found a complex correlation among the teachers' beliefs, such as in one side there are consistencies among suitable beliefs, but on the other side, there are some inconsistencies among suitable beliefs.

The complexity also occurs in the correlation between belief and practice in a mathematics class where the teachers' practices in a mathematics class do not always reflect the belief they hold. On one side, the teachers in this study tend to hold the belief of being constructivism-oriented, but on the other side they tend to use more traditional practices. The teachers appear more intent on doing instrumental teaching practice than relational practice. Instrumental teaching practice is very identical with a result-based learning than a process based one, so it often ignores relevant learning by the students' context. This finding strengthens earlier findings from researchers about Indonesian teachers' teaching practices in mathematics class (Purnomo, Kowiyah, Alyani, & Assiti, 2014; Purnomo et al., 2016; Wijaya et al., 2015) where it was found that the teachers' practices are more dominated with mechanistic practices. Wijaya et al. (2015) through a class observation found out that mathematics teachers' practices toward context-based tasks tend to be taught through directive approaches. The teachers are more dominating during the learning activity in class by giving problems, telling what should be done, and focusing on the mathematics solution without linking it to the context of the problem. Furthermore, the teachers also tend to do traditional assessments in the mathematics class. Traditional assessment practices refer to the practices that focus more on formality and accountability aspects than focusing on relevant learning practices or students' context. The teachers in this study tend to use summative tests as a part of the assessments and giving marks and scores on the students' worksheets as a form of feedback to the students. Some researchers (Purnomo, 2015, 2016b) agree that feedback such as constructive comments are more desirable and have a bigger positive impact on the students than giving marks or scores. Moreover, the teachers are also usually more intent on using external assessment standards than suitable standards for the students' real conditions. This surely separates assessment and learning.

Although the results of this research indicate that there are consistencies between the beliefs and practices of several factors, it is mostly dominated by inconsistencies between beliefs and practices in mathematics class. Similar findings can be found in an earlier research (Purnomo et al., 2016; Raymond, 1997) that the correlation between beliefs and practices is a complex correlation. Possible factors that potentially contribute to the inconsistencies between beliefs and practices can come from either internal or external factors. Some potential indications of internal factors are (1) the teachers' knowledge about the philosophy of mathematics and the learning perspective; (2) the teachers are hesitant to come out of their habit. The learning they conduct just focuses on fixed references (books or curriculum), causing the teachers to often think more of the risks than think of the relevant object or the learning context for the students; (3) mathematics knowledge for teaching. When the belief is not accompanied by the knowledge about how the content should be taught, the practice tends to follow experiences and fixed rules; and (4) experience, especially experience from becoming a student in school. Furthermore, the teachers also have a complex position so the practices conducted are often influenced by external factors, such as time pressure, curriculum, social norm, and learning environment. Another external factor which take part is high-stake accountability. Policy implementation often forces a teacher to adjust the practices to the rules which are often irrelevant with the context in the field. Excessive accentuation on result-based accountability causes educational stakeholders to ignore the process and in the end to fail to achieve the expected results, but also to go through an irrelevant process with the context.

Conclusion

The results of this research indicate that the teachers' beliefs are dominated by beliefs leading to constructivism view. Nevertheless, there are some evidences that the teachers' responses do not always consistently fall in one category. This research also finds complex correlations among belief dimensions and the correlation with practices in mathematics class. The implication can be identified and emphasized on two elements. They are government policy and teacher education program. The contradiction occurs when the government encourages the teachers to develop the curriculum. However, it turns out that the government acts as the curriculum developer. Teachers in Indonesia tend to be the curriculum implementers who wait for instructions as a form of their responsibility (see also Azis, 2014). Therefore, it is important for the government to try to understand and to build teachers' belief, knowledge, and literacy, and to respond to every education policy they make. It is also important for teacher education and development programs in Indonesia to focus on building the belief and mathematics knowledge for teaching, especially during the teacher candidate education period. The rational argument for this is that even though there is an excess of focus toward the content of a mathematical curriculum, the way those content are taught to elementary school students should not be disregarded.

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